

**Thermal Management for
Intel[®] Express 3D Graphics Card
(8MB Version)**

May 1998

**Reseller Applications Engineering
Reseller Product Division**

Information in this document is provided in connection with Intel product. No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Except as provided in Intel's Terms and Conditions, of Sale of such products, Intel assumes no liability whatsoever, and Intel disclaims any express or implied warranty, relating to sale and/or use of Intel products including liability or warranties relating to fitness for particular purpose, merchantability, or infringement of any patent, copyright or other intellectual property right. Intel products are not intended for use in medical , life saving, or life sustaining applications

Intel may make changes to specifications and product descriptions at any time, without notice.

Copyright © Intel Corporation 1998

*Third party brands and names are the property of their respective owners.

CONTENT

Introduction.....	4
Thermal Management.....	4
System Airflow	4
<i>Ventilation</i>	<i>5</i>
<i>Power supply air flow direction.....</i>	<i>5</i>
<i>Power supply fan strength.....</i>	<i>5</i>
<i>Auxiliary fan—should it be used?.....</i>	<i>5</i>
Auxiliary fan airflow direction.....	5
<i>Protect Against Hot Spots</i>	<i>5</i>
Overview of The 8MB Intel[®] Express 3D Graphics Card.....	6
<i>SDRAM vs. SGRAM.....</i>	<i>6</i>
<i>2oz CU vs. 1oz CU.....</i>	<i>6</i>
<i>Tall vs. Short Card.....</i>	<i>7</i>
<i>Summary of Changes.....</i>	<i>7</i>
Why You Should Test.....	7
<i>Test Setup</i>	<i>8</i>
Measuring Room Temperature	8
Applying The Thermal Indicator Label.....	8
<i>Downloading and Installing The Intel740TM Power Simulation Software.....</i>	<i>9</i>
Hardware Requirements	9
Operating System and Driver Requirements.....	9
<i>Downloading the Intel740TM Power Simulation Software</i>	<i>9</i>
Installing the Intel740TM Power Simulation Software Device Driver	9
Verifying Driver Installation.....	10
Un-Installing the Intel740TM Power Simulation Software Device Driver	10
Running the Intel740TM Power Simulation Software.....	10

FIGURES

Figure 1: An Example of System Airflow through ATX Tower Chassis (Side View)	4
Figure 2: 8MB Intel Express 3D graphics card.....	6
Figure 3: Heat Transfer For Intel740 TM on 8MB Intel Express 3D graphics card	7
Figure 4: Thermal Indicator Label.....	8
Figure 5: Backside of Intel Express 3D Graphics Card (8MB Version).....	9
Figure 6: Intel740 Power Simulation Software Screen Capture.....	10

TABLES

Table 1:Thermal Related Features / Components Difference on Intel [®] Express 3D graphics cards.....	6
Table 2: Temperature Conversion Table.....	11
Table 3: Test Result Summary Table.....	11

Introduction

This document is written for professional system integrators building PCs from industry-accepted motherboards, chassis, and peripherals. It provides information and recommendations for thermal management in systems using the 8MB version of the Intel® Express 3D graphics card. It is assumed that the reader has a general knowledge of and experience with PC operation, integration, and thermal management.

Thermal Management

All high performance desktop PCs *require thermal management*. The ultimate goal of this thermal management document is to keep the Intel Express 3D graphics at or below its maximum operating temperature. Integrators who follow the recommendations presented here can provide their customers with more reliable PCs and will see fewer customers returning with problems.

System Airflow

Airflow within a system is determined by the following elements:

- Chassis design, size, and location of chassis air intake and exhaust vents.
- Power supply fan capacity and venting
- Location of the processor slot(s)
- Placement of add-in cards and cables

There are a variety of chassis-motherboard-power supply combinations that an integrator can use (i.e. ATX, microATX, Baby AT, etc.). Intel recommends the use of ATX and microATX form factor motherboards and chassis that comply with the ATX 2.01 specification found on the (<http://www.teleport.com/~atx/>). MicroATX form factor specification can be found at (<http://www.teleport.com/~microatx/>). The ATX and microATX form factors simplify the assembly and upgrade of PCs, while improving the consistency of airflow through the entire system, including the AGP graphics subsystem. Figure 1 below shows an example of typical airflow through an ATX system.

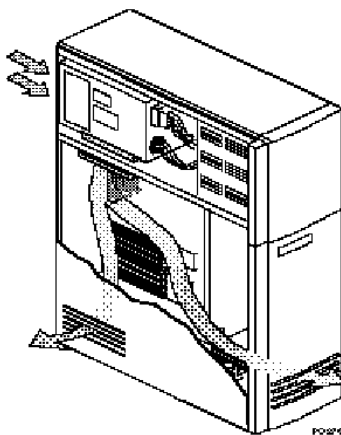


Figure 1: An Example of System Airflow through ATX Tower Chassis (Side View)

The following is a list of thermal guidelines to be used when integrating a system.

Ventilation

Systems must have adequate ventilation in addition to a fan. Chassis vents must be fully open and not cosmetic. Proper location of vents results in a good stream of air flowing over the processor and the add-in cards.

Power supply air flow direction

It is important to choose a power supply with a fan that moves air in the proper direction. For Baby AT system, the power supply fan acts as an exhaust fan, venting system air outside the chassis. For most ATX and microATX systems, the power supply acts as an intake fan, drawing air into the system.

Power supply fan strength

The strength of the fan within the power supply of a chassis plays an important role in drawing the air in and out of the system, creating an air flow within the chassis. For some chassis that do not pass the thermal test specified later on in this document, changing to a power supply with a stronger fan can greatly improve its condition. The strength of the fan is measured in Cubic Feet per Minute (CFM). Look for power supplies that contain fans with higher CFM number than the one used on your existing power supply.

Auxiliary fan—should it be used?

Some chassis may contain an auxiliary fan to assist airflow. An auxiliary fan is typically used for chassis that contain processors with a passive heatsink. If your chassis does not contain an auxiliary fan and it fails the thermal management test indicated later on in this document, add an auxiliary fan and retest your chassis.

Auxiliary fan airflow direction

When using a auxiliary fan, ensure that it moves air in the same direction as the overall system airflow. For example, if the power supply fan draws the air into the system, then the auxiliary fan should exhaust the air from the system. If the power supply fan forces air out of the system then the auxiliary fan should draw air into the system.

Protect Against Hot Spots

A system may have strong airflow through it, but still contain “hot spots”. Hot spots are areas within the chassis that are significantly warmer than the other areas within the same chassis. To minimize the risk of having hot spots within your selected chassis, utilize half length cards where ever possible, place full-length cards in slots farthest from the processor, and tie cables into tight bundles to ensure space is provided around and over the add-in cards and the processor.

Overview of The 8MB Intel® Express 3D Graphics Card

Figure 2 shows an assembly drawing of the 8MB Intel Express 3D graphics card.

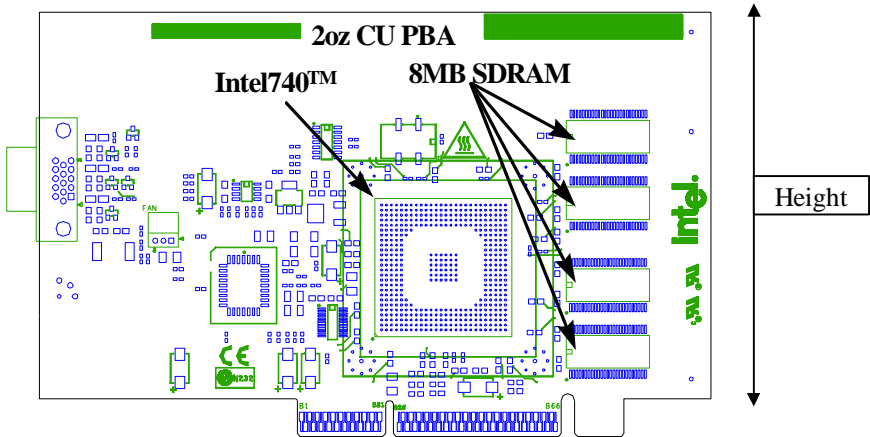


Figure 2: 8MB Intel Express 3D graphics card

The 8MB Intel Express 3D graphics card consists of 8MB of SDRAM local graphics memory for higher display color depth and resolutions. From the thermal perspective, the 8MB version does not contain the fan heat sink, previously seen on the 2MB and 4MB versions. The elimination of the fan heatsink is due to a taller circuit board with 2oz copper on its ground and power planes for better thermal management. Table 1 outlines the major differences between the 2MB / 4MB SGRAM version and the 8MB SDRAM version:

Features / Components	8MB Version	2MB/4MB Version
Graphics Engine	Intel740™	Intel740™
Local Graphics Memory	8MB (SDRAM)	2MB/4MB (SGRAM)
Copper Thickness (PBA)	2oz CU	1oz CU
Height as shown in Fig. 2	(3-7/8 inch) (9.9 cm)	(2-7/8 inch) (7.3 cm)
Cooling Fan	Not Required	Required

Table 1: Thermal Related Features / Components Difference on Intel® Express 3D graphics cards

Following is an explanation of how each change on the 8MB version as is listed in Table 1, contributes to improved thermal performance, and therefore the removal of the fan heatsink.

SDRAM vs. SGRAM

Typically, SDRAM memory dissipates less heat than SGRAM memory. This change allows for lower overall thermal stress on the card. The 8MB version of Intel Express 3D graphics card uses 8MB of SDRAM.

2oz CU vs. 1oz CU

The Intel740™ graphics accelerator chip on the Intel Express 3D graphics card uses a Ball Grid Array (BGA) package. The primary heat dissipation path for BGA packages is through thermal balls into the power and ground planes in the circuit board where the heat dissipates as it travels away from the Intel740™ accelerator (See Figure 3). Since the power and ground layers in this case are the heatsink for the Intel740™ accelerator, having thicker copper (i.e. 2oz) creates a better heatsink. The new 8MB version

of the Intel Express 3D graphics card uses 2oz copper for power and ground layers rather than 1oz copper used on the 2MB/4MB versions.

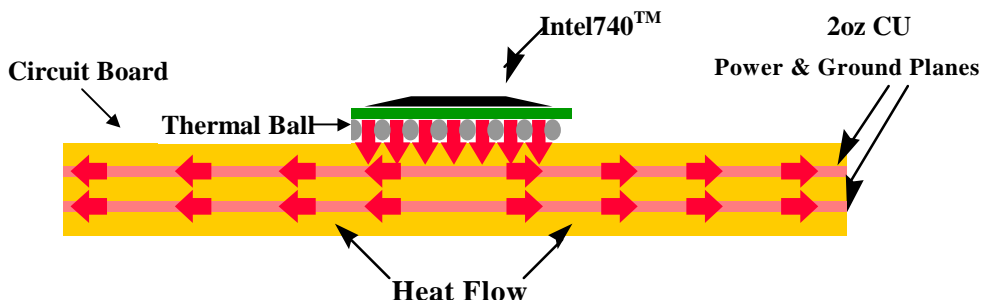


Figure 3: Heat Transfer For Intel740™ on 8MB Intel Express 3D graphics card

Tall vs. Short Card

As it was discussed in the previous section, in the case of Intel740™ accelerator, the circuit board is a heatsink. In order to improve the heat dissipation throughout the graphics card, the height of the card was increased by 1 inch/2.6 cm to the full height allowed by the ATX form factor. This change, in addition to the thicker copper, creates an excellent heatsink for Intel740™ accelerator. Figure 5 shows the area around the component in white where heat dissipates into. Additionally, the taller card catches more air it travels above the add-in card in a given chassis.

Summary of Changes

In summary, the changes in the 8MB version of the Intel Express 3D graphics card creates an environment where heat is dissipated within the circuit board in the following steps, eliminating the need for having an active heatsink (i.e. fan heatsink)

- 1. Intel740™ accelerator BGA packages is designed to dissipate heat into the circuit board.
- 2. The new circuit board used on the 8MB version contain 2oz copper vs 1oz copper on the 2MB/4MB versions
- 3. Copper is a good conductor of heat and therefore it transfers the heat away from the Intel740™ accelerator and dissipates it as it travels through out the circuit board.
- 4. The new 8MB version is taller (full ATX height) and therefore has more circuit board to dissipate heat into. It also catches more air as it stands taller within the chassis.
- 5. Circuit board becomes the heatsink and therefore eliminating the need for having a fan on the Intel740™ accelerator

Why You Should Test

The 8MB version of Intel Express 3D graphics card relies on the air flow and the ambient temperature inside the chassis to adequately cool its Intel740™ graphics accelerator. Variations in motherboards, power supplies, and chassis all affect the operating temperature of system components and ambient temperature inside the chassis. Thermal testing is highly recommended to validate the choices of new motherboards, chassis, or when starting to use new system peripherals. Thermal testing can show if a specific chassis, power supply, and motherboard configuration provides adequate airflow for the 8MB version of the Intel Express 3D graphics card.

Test Setup

There are three steps in setting up to measure the operating temperature on 8MB Intel® Express 3D graphics card. First, the temperature in the room where the test will be conducted is measured. Second, the thermal indicator label is applied on the back side of the 8MB card. Third, a thermally stressful software application called “Intel740™ Power Simulation Software” is loaded onto the system under test. This power simulation software, thermally stresses the Intel740™ on your 8MB version of Intel Express 3D graphics card while it is running. Following are the explanation for each step

Measuring Room Temperature

Before starting to test your system configuration, you will need to measure the temperature of the room where the test is to be conducted. To do this, you will need a digital thermometer. Record the room temperature as you will need it later on in this procedure for calculating the operating temperature of the 8MB Intel® Express 3D graphics card. (Table 2 contains a table for converting between Fahrenheit and Celsius scales.)

Applying The Thermal Indicator Label

Figure 4 shows a thermal indicator label. Each label has a range of temperature indications, from 40°C to 80°C in 5°C increments. The indicated temperature on the thermal indicator label change color from white to red as corresponding temperature is reached. Once a temperature level has been reached and the color has been changed from white to red, it remains at that color, allowing the viewer to record the maximum temperature reached during the test.

The Thermal Indicator Label can be purchased (Part Number I-602) from the manufacturer: American Thermal Instruments Inc. at the following address; American Thermal Instruments Inc., 9 Huffman Ave., P.O. Box 353, Dayton, OH, 45401 USA. Phone: (937) 252-0548. Fax: (937) 252-6509

(For small quantities, please see your Intel Customer Representative.)



Figure 4: Thermal Indicator Label

- 1) Apply the thermal indicator label to the back side of the 8MB card in it’s designated location, as is shown in Figure 5.

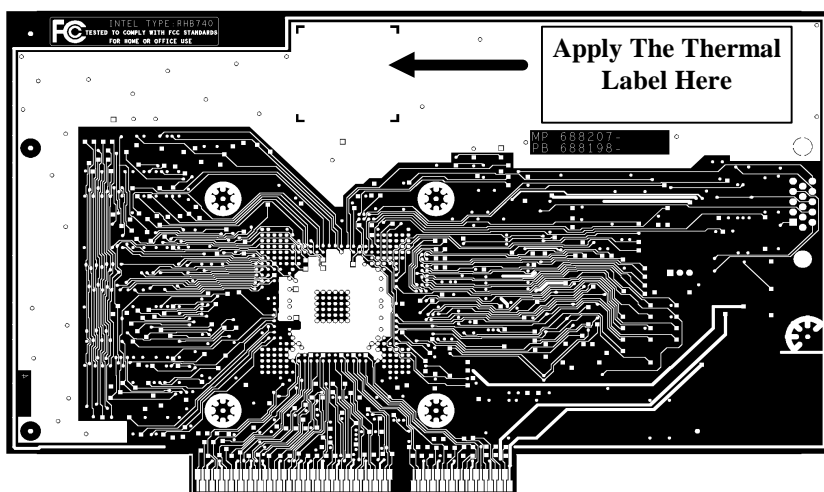


Figure 5: Backside of Intel Express 3D Graphics Card (8MB Version)

- 2) Install the 8MB Intel Express 3D graphics card into the system under test
- 3) Enclose the chassis as it is intended to be shipped to your customer by placing all of its covers

Downloading and Installing The Intel740™ Power Simulation Software

Hardware Requirements

The Intel740™ Power Simulation Software will only run on a system with the Intel740 Graphics Controller installed as the primary display controller. In addition, the Intel740™ Power Simulation Software Driver must be loaded per instructions listed later in this document.

NOTE: The Intel740™ Power Simulation Software requires that the system under test utilize an Intel 440LX or 440BX AGP set, with the host bus clock frequency set to 66 or 100 MHz.

Operating System and Driver Requirements

The Intel740™ Power Simulation Software **requires Windows* 95 (OSR 2.1) with USB Supplement** and DirectX * version 5.0 or later to be installed on the system under test. *(The current version (1.0), does not operate under Windows* 98 or Windows NT*)*

Downloading the Intel740™ Power Simulation Software

Intel740™ Power Simulation Software can be download from <http://channel.intel.com/business/ibp/private/dvd/downloads/740pwrdr.zip>. The file is called "740pwrdr.zip"

Installing the Intel740™ Power Simulation Software Device Driver

- 1) Uncompress the "740pwrdr.zip" file, using WinZip or Pkunzip, into a single directory.
- 2) Click on "My Computer" icon on your desktop and select "Control Panel"
- 3) Click on "Display" icon and select "Settings"
- 4) Click on "Advanced Properties" button and select "Adapter" tab
- 5) Click on "Change..." button
- 6) From the new window, click on the "Have Disk" button and direct the "Install From Disk" directory to the location where the uncompressed "740pwrdr.zip" is located and press OK

Note: A warning message may be displayed, stating the fact that you are about to change a new driver with an older one. Ignore this message and continue by pressing “Yes” or “OK”

- 7) At the next window, a message stating “Intel740 Memphis SDR Beta 2.7 drivers are about to be installed”. Click the “OK” button to accept the display driver change, and then click the “Close” button in the “Advanced Display Properties” window as well as the “Display Properties” window to completed the installation.

Note: A message may be displayed, stating that “Windows detects that your current driver may be closer match for your hardware device than the driver you have selected. Are you sure you want the driver you have selected?”. Press “Yes”

- 8) Restart the computer when prompted to do so.

The Inte740 Power Simulation Software Driver should now be loaded onto your system under test. To determine if the driver has successfully been installed, refer to the following section.

Verifying Driver Installation

- 1) From the Windows desktop, click on “My Computer” than “Control Panel” icons
- 2) Click on “System” and than “Device Manager” icons
- 3) Click on “Display Adapter” .

The display adapter should read “Intel740 Memphis SDR Beta 2.7”. If this is not the case, the driver will need to be re-installed.

Un-Installing the Intel740™ Power Simulation Software Device Driver

- 1) From the Windows desktop, click on “My Computer -> “Control Panel” and then “Add / Remove Program”
- 2) Click on “Intel740 Graphics Accelerator” and then “Add / Remove” button
- 3) Follow the instructions by clicking on “Yes” as indicated
- 4) The drivers and configuration managers should not be un-installed. After this, the Intel Express 3D graphics card driver can be loaded.

Running the Intel740™ Power Simulation Software

- 1) Go to the directory where the “740pwrdr.zip” is uncompressed and double click on “740power.exe”
Ensure that the version number shown is 1.0.
- 2) Once you have verified the version number, click on “OK” button to start the test
- 3) After the start of the program, the sphere shown in Figure 6 remains motionless. Allow the test to continue for **45 minutes**.

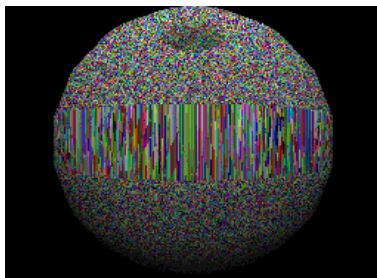


Figure 6: Intel740 Power Simulation Software Screen Capture

- 4) After the completion of the test, press the “Escape” button to terminate the test
- 5) Turn the system off, remove the 8MB Intel Express 3D graphics card and record the lowest temperature that remains white.

- 6) Using this temperature and the room temperature you have measured in previous steps, compare your results with the range listed in Table 3 in order to identify if your system has passed or failed the thermal management test.

°F	°C	°F	°C	°F	°C	°F	°C
59	15	93	34	127.4	53	161.6	72
61	16	95	35	129.2	54	163.4	73
62.5	17	97	36	131	55	165.2	74
64.5	18	98.5	37	132.8	56	167	75
66	19	100.5	38	134.6	57	168.8	76
68	20	102	39	136.4	58	170.6	77
70	21	104	40	138.2	59	172.4	78
71.5	22	105.8	41	140	60	174.2	79
73.5	23	107	42	141.8	61	176	80
75	24	109.4	43	143.6	62	177.8	81
77	25	111.2	44	145.4	63	179.6	82
79	26	113	45	147.2	64	181.4	83
80.5	27	114.8	46	149	65	183.2	84
82.5	28	116.6	47	150.8	66	185	85
84	29	118.4	48	152.6	67	186.8	86
86	30	120.2	49	154.4	68	188.6	87
88	31	122	50	156.2	69	190.4	88
89.5	32	123.8	51	158	70	192.2	89
91.5	33	125.6	52	159.8	71	194	90

Table 2: Temperature Conversion Table

FAIL Lowest Temp. in White From The Label (°C)	PASS Lowest Temp. in White From The Label (°C)	At Room Temperature (°C)
≥60	55	12 - 17
≥65	60	17 - 22
≥70	65	22 - 27
≥75	70	27 - 32
≥80	75	32 - 37

Table 3: Test Result Summary Table

If your test results indicates a failure per Table 3, consider improving the system thermal management or choosing a different chassis for installation of the 8MB Intel Express 3D graphics card.

It is important to note that at temperatures above the passing rates, specified in Table 3, the other components within your chassis, including the processor may be exposed to higher than maximum operating temperatures. It is highly recommended that you consider using a different chassis or modifying your existing chassis in order to build a reliable system.